Defense Technical Information Center Compilation Part Notice

ADP015008

TITLE: Electronic Circuits during Oscillations of an Anode Double Layer

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: International Conference on Phenomena in Ionized Gases [26th] Held in Greifswald, Germany on 15-20 July 2003. Proceedings, Volume 4

To order the complete compilation report, use: ADA421147

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, etc. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP014936 thru ADP015049

Electronic circuits during oscillations of an anode double layer

Valentin POHOAȚĂ, Gheorghe POPA, Roman SCHRITTWIESER* and Codrina IONIȚĂ *

Plasma Physics Department, "A. I. Cuza" University, Bd. Carol I No. 11, RO-6600 Iaşi, Romania
*Institute for Ion Physics, University of Innsbruck, Technikerstr.25, A-6020 Innsbruck, Austria

A so-called fireball is formed in front of a positively biased planar electrode (anode) inserted into a diffusive plasma produced by a multipolar confinement system. We have investigated the entire electronic circuit, through which the current is flowing during the nonlinear oscillations of the fireball. An annular ring electrode placed in front of the anode allows the identification of the ionic or electronic nature of the currents flowing through some parts of the circuits.

1. Introduction

A fireball (FB) is a localized zone of higher plasma density and luminosity, confined by an anode double layer (DL), which is produced by additional excitation and ionization processes due to electrons accelerated towards a positively biased electrode, immersed in a homogeneous low density plasma [1]. Recently, new results on the control of fireball oscillations have been reported [2], whereas the process of formation and the dynamic of these plasma formations was related to self-organisation processes [3]. Here we present experimental results about the electronic circuits involved in the oscillations of the fireball.

2. Experimental set-up

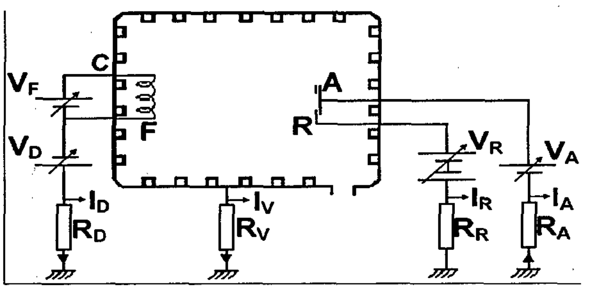

Fig. 1 *Schematic of the Iasi single multipolar confinement plasma machine. The Rd, Rv,Rr and R a are of the order of 10 ohm.*

The experiments were carried out in the multipolar plasma machine of the University of Iaşi (Fig.1). The cylindrical vessel has a diameter of 30 cm and 40 cm length. A diffusive argon plasma is produced by a hot cathode discharge inside a magnetic multiple polar confinement system, between the tungsten filament (F) as cathode (C) and the cylindrical wall as main anode. Operating parameters were: gas pressure $p = 10^{-3}$ mbar, discharge voltage $V_D = -50 \div -80$ V, discharge current within the range of $I_D = 10 \div 40$ mA.

Typical plasma parameters measured by both, Langmuir and emissive probes, were: plasma potential with respect to the grounded anode $V_p \cong +1.5$ V, plasma density in the range of $n = (1 \div 5)\times10^8$ cm^{-3} and electron temperature $T_e = 1.5 \div 2$ eV. A plane Ta-electrode (A) with a diameter of 1 cm was inserted into the plasma and biased positively ($50 < V_A < 250$ V) to create the fireball.

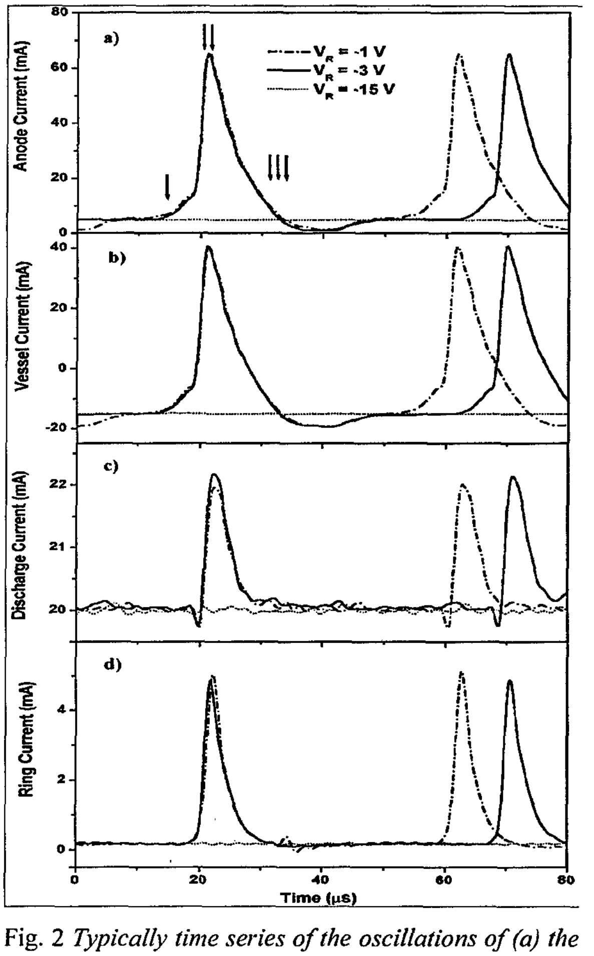

Fig. 2 *Typically time series of the oscillations of (a) the anode current I_A ; (b) the vessel current I_V (for the sake of clarity with inverted sign) (c) the plasma discharge current I_D and (d) the ring current I_R (ionic current) $V_A = 145$ V, $n = 1.5\times10^8$ cm^{-3}. For $V_R = -15$ V (dotted line) no fireball is formed and the plasma is stationary.*

An additional ring-shaped electrode R of 2.5 cm external diameter and 1 cm inner diameter was mounted concentrically 0.2 mm in front of the electrode A in order to control the oscillations [2] and to identify the nature of currents involved in the mechanism of the formation and dynamics of the fireball. Moreover, the experimental arrangement permits the electrical separation of the discharge vessel or main anode from ground so that also the vessel current I_V can be measured together with the discharge current I_D, the anode current I_A and the ring current I_R, respectively.

3. Experimental results

Typical steady state (dotted lines) and oscillatory behaviours (full lines) of the currents I_A, I_V, I_D and I_R are presented in Fig. 2. They show a relaxation type oscillation, similar to that reported by Bin Song et al. [1], with the peak current (labelled II) being about one order of magnitude larger than the minimum (labelled I) of I_A. The oscillations are characterised by a fast increase (I to II), when the fireball is forming, and a slower decay (II to III) when it disappears.

In the steady state regime or during the minimum of the anode current (labelled as III in Fig. 2), when the conditions for the fireball formation are not given, the discharge works as a simple d.c. hot cathode discharge with two anodes: the electrode A and the discharge vessel (= main anode).

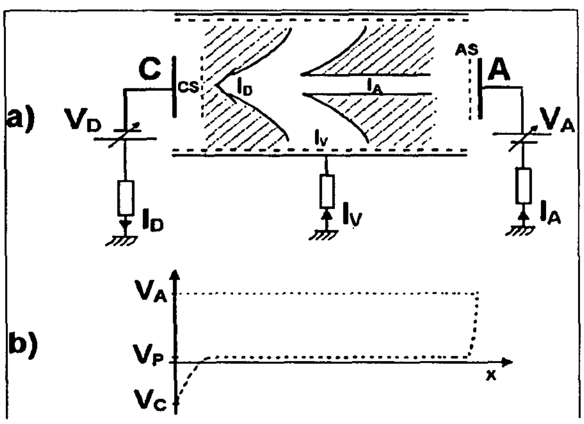

Fig. 3. *Schematic diagrams of the main currents (a) and of the axial potential profile (b) between the cathode C and anode A for a one-dimensional model for both, the steady state regime and the dynamic regime, without fireball (slow phase).*

The plasma is rather homogeneous in the chamber with a potential of about +1.5 V with respect to the main anode but separated from the hot cathode by the ion-rich space charge (CS) of the cathode fall and by a thin electron-rich space charge (AS) from the anode. The discharge current I_D, measured in the circuit of the cathode, is given by:

$$I_D = I_A + I_V, \tag{1}$$

where I_A is the current through the anode A and I_V is the current flowing through the main anode. A possible circuit, including the main anode and anode A is equivalent to a plane probe (anode A) biased positively with respect to the reference electrode (discharge vessel) and its current might be neglected with respect to the main discharge current.

During the fireball formation there is an important change in the electronic circuit. In Fig. 4 a schematic diagram is presented of the currents (a) flowing in the system during the maximum of the anode current I_A during its oscillations, and of the corresponding potential profile (b).

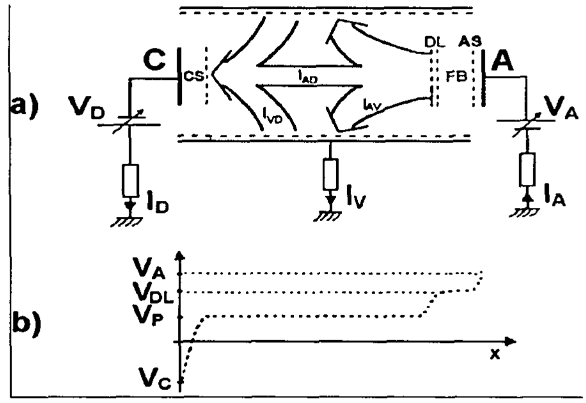

Fig. 4. *Schematic diagrams of the main currents (a) and of the axial potential profile between the cathode C and the anode A in one-dimensional model during the maximum of the anode current in the oscillatory regime. V_A, V_{DL}, V_P are the potentials of the anode A, of the plasma in the fireball region and of the main plasma region, respectively.*

In this case the fireball reaches its maximum spatial extension of about 7 cm in front of the anode [2], and the axial profile of the plasma potential corresponds qualitatively to Fig. 4b. In this case the electrons accelerated towards the anode A produce ionisations and excitations of the argon atoms so that the fireball region consists of a rather high density and luminosity plasma region, separated from the anode by a thin electron-rich sheath (AS) and from the main plasma by a double layer (DL). The potential drop across the latter ($V_{DP} - V_A$) is of the order of the ionisation potential of argon. Also important is the fact that during this stage the plasma potential in the main chamber increases significantly by some tens of volts so that the role of the discharge vessel is strongly changed. It might be considered as a cold cathode in a circuit which contains the anode A and the discharge vessel. In this case the main result is that equation (1) for the main discharge current remains valid but this time I_V is an ionic current as also the ring current I_R (Fig. 2d).

Acknowledgement This work was supported by the contract grant CNCSIS/2002.

4. References

[1] Bin Song, N. D'Angelo and R.L. Merlino, *J. Phys. D: Appl. Phys.* **34**, 1789 (1991).

[2] V. Pohoaţă, G. Popa, R. Schrittwieser, C. Ioniţă and P.C. Balan, *Proc. Joint Conf. ESCAMPIG 16 and ICRP 5* (Grenoble, France, 2002), Contr. Papers, vol. 2, p. 187.

[3] C. Avram, P.C. Balan, M. Sanduloviciu, R. Schrittwieser, *Proc. XXIVth Int. Conf. Phenomena in Ionized Gases* (Warsaw, Poland, 1999), Vol. I, p. 11.